

AP9641

requested. It is believed that the substitute specification and new claims will facilitate processing of the application in accordance with M.P.E.P. 608.01(q). The substitute specification and new claims are in compliance with 37 CFR 1.52 (a and b) and, while making no substantive changes, are submitted to conform this case to the formal requirements and long-established formal standards of U.S. Patent Office practice, and to provide improved idiom and better grammatical form.

The enclosed substitute specification is presented herein in both marked-up and clean versions.

STATEMENT

The undersigned, an attorney registered to practice before the office, hereby states that the enclosed substitute specification includes the same changes as are indicated in the mark-up copy of the original specification. The substitute specification contains no new subject matter.

Respectfully submitted,



Joseph V. Coppola, Sr. Reg. No. 33,373
Alexander D. Rabinovich Reg. No. 37,425
Rader, Fishman and Grauer PLLC
39533 Woodward Ave., Suite 140
Bloomfield Hills, Michigan 48304
(248) 594-0650
Attorney for Applicants

R0128902.DOC

0 80665 .111501

09/980665

JC10 Rec'd PCT/PTO 1 5 NOV 2001

SUBSTITUTE SPECIFICATION: MARKED UP COPY

AP9641

[PC 9641]

Sensor Unit and Sensor for Such a Unit

Technical Field

The present invention generally relates to sensors and more particularly relates to sensor assemblies that include signal processing circuitry [relates to a sensor unit as well as a sensor for such an unit according to the preamble of patent claim 1 and the preamble of claim 6, respectively].

Background of The Invention

It is intended to realize a unit for various sensoric arrangements or sensors for the detection of dynamic air gap changes with a general design concept, where the unit comprises shelf parts or ready-made sensors.

The invention generally serves applications in the area of mechanical engineering, [yet] particularly for brake and driving-dynamics systems in the automotive industry, and here primarily in the application sector of controlled systems with brake intervention like ABS and TCS. The main application sector, however, is the employment for ESP (driving stability control systems) and SWT (Sidewall Torsion, in which, for the determination of wheel forces and of wheel speed, the tire sidewall deformation of an motor vehicle wheel is measured via sensors and evaluated).

A specific tire suitable for SWT and an SWT sensor, respectively, are known from DE 196 20 582 A1 and DE 196 20 581 A1. Also known in the prior art are magnetically active machine parts for air gap modulation, in which basically all permanent-magnetic or ferromagnetic parts can be utilized, which are moved in the direction of the air gap in dependence on a physical quantity to be measured. Usually incremental encoders are used for this purpose. There is a distinction between ferromagnetic and permanent-magnetic encoders.

AP9641

Ferromagnetic encoders are, for example, toothed wheels, toothed washers, toothed rings or hole-punched discs. Permanent-magnetic encoders are usually ring-shaped or circular arrangements of successive north/south pole areas embedded in rubber or some other mechanical carrier.

Substantial examples for the use of magnetized encoders are magnetized wheel bearing seals for an ASB system ("Active Sensor Bearing") for the detection of the wheel speed and the magnetized vehicle wheel, already mentioned above, for the detection of dynamic forces according to the SWT principle (Sidewall Torsion Sensors).

Sensor arrangements for the detection of air gap modulations by means of an encoder are generally known. For instance, they also serve for the determination of crankshaft and camshaft positions in motor vehicle engines. In another [classical case of] typical application[,], for the measurement of wheel speeds, an incremental encoder track periodically modulates the magnetic field strength in the air gap between two fixed values. An additional change of the kinematics between the sensor and the encoder through dynamic forces during driving operation and the herewith additionally occurring modulation of the field strength is undesirable in this application and is suppressed during signal-conditioning.

To this end, the so-called active sensors known from the prior art for ABS wheel speed detection contain an internal amplifier/trigger circuit that effects that, regardless of the air gap dynamics, always a square wave signal with two possible states [constant amplitudes] is generated, whose edge change follows the encoder track.

For the detection of driving-dynamical states (ESP) of a motor vehicle, e.g. during cornering, it is suggested, for example in DE 44 42 355 A1, to draw on the value of an elastic axle deformation and, for its measurement, to use the width of the air gap between a wheel speed sensor and its respective encoder.

For the determination of longitudinal and lateral forces, it is known from DE 44 35 160 A1 to detect as well the phase of two wheel speed sensor signals as their variable signal amplitudes on a magnetically encoded tire [via] by way of air gap deformations.

AP9641

[Further advantages and preferred embodiments of the present invention arise from the subclaims as well as from the following description in connection with the attached drawings. In the drawings,]

Brief Description of The Drawings

- Fig. 1 a shows a basic structure of the inventive sensor unit[;].
 Fig. 1 b-c show different variants of sensors based on the same concept[;].
 Fig. 2 a-b show schematic illustrations of sensor circuits with functional blocks[; and].
 Fig. 3 a-b show the course of signal currents J_1 and J_2 over the time.

Detailed Description of The Preferred Embodiments

In connection with Fig. 1 a-d, at first a general concept for the standardized design of units for the active-sensor scanning of encoders is described, which are processed into ready-made sensors (probes) or which comprise common modular units according to the invention, respectively.

Fig 1a shows an outer housing shape or basic structure, respectively, of a general sensor element according to the inventive design concept. Here reference numeral 1 identifies a housing or head 1, preferably made of plastic, in which a [always some] magneto-electric converter element is embedded. [2 identifies a] A housing 2, preferably made of plastic, that [further on will also be] is also called body 2. [In body] Body 2, [there is always] contains some embedded [some] electronic signal processing circuit. The intended application determines what converter element is contained in head 1 and what signal processing circuit in body 2. A permanent 4-pole electric connection 3 extends between head 1 and body 2. For a 2-wire connection to a control device, a pin 4 serves as signal output and a pin 5 for the supply with operating voltage.

AP9641

Figures 1b, 1c, and 1d show the general housing shape according to Fig. 1a combined with three differently sized magnets 6, 7, and 8. These magnets serve for the demand-assigned different magnetic pre-load of electro-magnetic converters in head 1. Following the inventive thought of the design concept, three different magnets 6,7,8 have fixed dimensions so that general design variants exist now, whose content can be exchanged or adapted in head 1 or body 2 according to the application.

In an advantageous application, the constructive dimensions of the design variants correspond at the same time those of already existing active wheel speed sensors.

A further advantage of the inventive design concept consists in always realizing the following four interface properties. A 2-wire connection to the control device, operation with a wide range of uncontrolled supply voltage, load-independent current as carrier of the output signal as well as a continuous frequency resolution up to the standstill of the encoder.

Preferably, magneto-electric converters are exclusively used which are based on XMR technologies (concerning this, see Verlag VDI-Technologiezentrum, Düsseldorf, "Technologieanalyse Magnetismus", Vol. 2). Here particularly AMR technology (anisotropic magneto-resistance) and GMR (giant magneto-resistance).

The design variants are consistently used with a significant advantage as follows: The variant according to Fig. 1a in combination with permanent-magnetic encoders, the design variant according to Fig. 1b in combination with ferromagnetic encoders, the design variant according to Fig. 1c in combination with ferromagnetic encoders, and the variant according to Fig. 1d in combination with permanent-magnetic encoders.

Applications of the new design concept according to the invention are, among others, active wheel speed sensors with digital offset compensation according to patent application DE 198 15 084 A1, in which the head 1 comprises a magneto-resistive bridge and a [Barber] barber pole structure as well as an ASIC for digital offset compensation. ASICs are integrated circuits (ICs) specifically designed for the application.

AP9641

Additionally, the invention is suitable for active wheel speed sensors with transmission of additional information and a novel data protocol according to DE 196 34 715 A1. A head 1 with magneto-resistive bridge and [Barber] barber pole structure, in which an IC or ASIC is employed for the recognition of direction and for the diagnosis of the air gap[, is also conceivable].

[Another conceivable application of the] The inventive sensor unit [is] can also be employed as an active sensor for the simultaneous detection of wheel speed and dynamic air gap deformation. Such a sensor can be utilized with a significant advantage for ESP or SWT, respectively. In this case, the sensor preferably includes a head 1 with a magneto-resistive bridge and a body 2 with an ASIC, in particular of the type UA1272. Preferably, this sensor is designed according to one of the design variants according to Fig. 1 b-d.

Subsequently, such a sensor according to the invention as well as its adaptation to the inventive concept of the sensor units is described in further detail. The intended components of realization are mentioned in the preceding paragraph. [The variants of the constructive completion follow the guideline of the design concept claimed by the invention].

As previously explained, There are sensor elements for active wheel speed sensors, which can be integrated into the design concept and are currently manufactured in large numbers. To this end, Fig. 2b shows a schematic illustration of an electronic circuit with functional blocks of [a n] an active wheel speed sensor, and Fig. 2a shows a schematic illustration of the sensor according to the invention. Both depictions show at the same time the constructive allocation of the functional blocks into the superordinate design concept according to Fig. 1.

Preferably the same crystal module should be used for the detection of the air gap modulation that is already present as a standard component of sensor elements for active ABS wheel speed sensors and manufactured in large numbers. This yields the economic advantage that also small SWT equipment numbers can be served more economically. At the same time, the total number of crystal modules produced is increased[, which become cheaper that way] (reducing the cost per unit).

AP9641

Both heads 1 contain a magnetoresistive bridge circuit 9 of the same type. The magneto-electric converters 9 are, [via] by way of an air gap not depicted here, magnetically coupled to a permanent-magnetic encoder track 10, which is preferably arranged in the sidewall of a magnetized tire or in a magnetized wheel bearing seal. The heads 1 are connected to the bodies 2 through the mentioned 4-pole connections 3. To the respective control device, there is the above-mentioned 2-wire connection via pin 4 and pin 5.

The voltage supply V_{cc} is established [via] by way of the respective pin 5 from an electric control or regulating unit for the brake system. The signal processing circuits contained in bodies 2 differ by the schematically shown units 12 and 13 so that the signal currents J_1 and J_2 are significantly different[, too].

In the known active sensor according to Fig. 2b, every fluctuation of amplitude, caused by dynamic air gap deformation, is suppressed by an amplifier or trigger stage, and the signal is shaped into an accurate, load-independent rectangular signal current J_2 with two constant amplitudes so that the transmitted information is limited to the wheel speed which is mapped in the sequence of edges.

In the inventive arrangement according to Fig. 2a, however, there is located an electronic circuit 12 amplifying and processing the signal so that a signal current J_1 is supplied to the control device 11, from which signal current additionally, beside the wheel speed information 14, the gauge of the amplitude can be gathered as a measurement for the thickness of the air gap 15 and the phase relation 16 to a reference signal.

Figs. 3a and 3b clarify once more the differences of the signal currents J_1 and J_2 between the known active sensor of Fig. 3b and the inventive sensor according to Fig. 3a under the same interface conditions to the encoder. Under the presumption of an air gap variation shown here, both sensors map the same wheel speed, however, only the inventive sensor additionally also the amplitude changing with the air gap width.

AP9641

In an advantageous embodiment of the invention for the realization of an SWT sensor, the previously described arrangement can for instance be designed according to the following characteristics:

[To this end, the SWT sensor has]

- a magnetic sensitivity (output current amplitude/encoder field strength) of $S = .75 \text{ mA/[kA/m][,]}$
- an output current amplitude range of $J = 11 \text{ mA} \pm 4 \text{ mA lift[,]}$
- a terminal voltage range at pin 4 of $V_{CC} = 5 \text{ to } 16 \text{ V[, and]}$
- an output impedance of $\geq 10 \text{ kOhm}$.

The magnetized tire sidewall as encoder track can, for instance, be equipped with a pole pattern of 48 north/south pole pairs per 360° sidewall and with a magnetic field strength amplitude of .8 kA/m at 10 mm air gap.

In an advantageous embodiment of the invention for the realization of an SWT sensor, the sensor arrangement is realized according to the inventive design concept by utilizing the following units. Head 1 comprises a magnetoresistive bridge 9, body 2 includes an ASIC of the type UA1272. Preferably, the sensor is designed according to the embodiment of Fig. 1b, 1c, or 1d.

AP9641

[Abstract]

Sensor Unit and Sensor for Such a Unit

Abstract of The Invention

The invention relates to a sensor unit and a sensor for such a unit for vehicles, in particular motor vehicles. According to the invention, in order to provide a concept equally suitable for different sensor types, in which modular sensor units are formed and whose basic system is suitable for all sensors, a first housing [(1)] for the accommodation of at least one converter element a second housing [(2)] for the accommodation of a signal processing unit, an at least 4-pole connection [(3)] between the first and the second housing, and a port [(4,5)] of the second housing [(2)] for a control device are provided.

[(Fig. 1)]